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Preliminary Results of an Analysis of Areas of Influence in Shanghai

by

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ABSTRACT

The main deficiency of most current modeling approaches to transportation can be identified as neglect of the integration of existing geographical knowledge in regard to the ex ante transport/land use modeling approaches, with its focus on territorial dynamics and theory development. This paper addresses this aspect of the problem by introducing a theoretical and methodological framework for the analysis of the interrelationship between land uses. The analysis attempts to determine to what extent the functional land use in a city can be considered an ordered pattern. The order sought does not rely on purely spatial configurations, but on the correlation of transportation and land use. The first section of this paper focuses on theoretical considerations. It stresses the fact that conventional approaches do not apply in the present context. It then suggests an alternative based on areas of influence and measured in terms of level of attractance of land uses. The second section describes a procedure based on this alternative following the remarkable contribution of Hanjoul, Beguin and Thill. An application of this procedure to the analysis of Shanghai is then examined. Finally, an evaluation of the strategies for optimizing the interrelationship between land uses is presented. The paper concludes with a possible research agenda.

Key words: Land use, transportation, distances, Shanghai.

RÉSUMÉ

Le principal défaut des approches de modélisation en transport peut être identifié comme une négligence d'intégrer d'abord les connaissances géographiques existantes en égard aux approches de modélisation transport/utilisation du sol, avec une attention sur la dynamique territoriale et le développment théorique. Cet article s'adresse à cet apect du problème en introduisant un cadre théorique et méthodologique pour l'analyse de l'interrelation entre les différents types d'utilisation du sol. L'analyse tente de déterminer dans quelle mesure l'utilisation fonctionnelle d'une ville peut être considérée comme une structure ordonnée. L'ordre recherché ne repose pas purement sur une configuration spatiale, mais sur la relation entre le transport et l'utilisation du sol. La première partie du manuscrit porte sur des considérations d'ordre théorique. Nous soulignons que les approches conventionnelles ne s'appliquent plus dans le contexte actuel. Nous suggérons ensuite une alternative basée sur les aires d'influence et mesurée en termes de niveau d'attraction des utilisations du sol. La seconde partie décrit la procédure basée sur cette alternative à la suite de la contribution remarquable de Hanjoul, Beguin and Thill. Une application de cette procédure à l'analyse de Shanghai est ensuite examinée. Enfin, une évaluation des stratégies pour optimiser l'interrelation entre les utilisations du sol est présentée. L'article conclut sur un agenda de recherches possibles.

Mots-clés: Utilisation du sol, transport, distances, Shanghai.

PRELIMINARY RESULTS OF AN ANALYSIS OF AREAS OF INFLUENCE IN SHANGHAI

1. INTRODUCTION

Since 1975, the industrialization phenomenon has met with a crisis affecting all of its components: territorial, economic, political, and social. This crisis is the result of two factors. Firstly, a greater division of production compelled by the ageing of industrial infrastructures brought about a profound transformation in the functioning conditions of the international economic system. The most important change resides in the reduction of the use of raw material in the production of goods and energy. The systematic search for energy saving in all fields of economic activities has accelerated the substitution of information in place of raw material, energy and labor power. This has been the case for most heavy industries around the world, especially those depending on international trade and exchange. Territorial specialization is the second cause of this situation. The world market tends to fragment the labor process. A disintegration of production characterized by an increase in subcontracting is observed. The international division of capital operates through a tangling of functions in various countries, often within the same firm. The necessary integration of industries that follows is so intense that the difficulty affecting one component has an impact on the whole system (Scott and Storper, 1986). One of the consequences of this tendency on the organization of industrial space is the fundamental role played by ports with regards to the international exchanges. But there exists a profound functioning discrepancy between the world production system and individual urban units. Armstrong and McGee (1985) have demonstrated how the pressing need for a production rhythm and logic finds its root at the world

level and as such is foreign to national urban systems. As a result, the reorganization of city ports leads to extremely complex operations given the space already in use, the size of sites, the cost of land use change and relocation, and the diversity and heterogeneity of actors.

The creation of major harbor complexes, whose accessibility is progressively adapting itself to the needs of the world maritime transport system and the establishment of industrial units upstream, has led to major operations of territorial planning that influence geographical space in Third World countries. The underlying strategy is the practice of the growth pole theory with which territories could be enriched and developed. But the international division of labor gives to countries producing raw materials and energy and having an important reserve of poorly qualified labor power an outmoded advantage, not the advantage of a capacity to innovate in the most evolved form of industries. Besides, given the degree of disfunction of Third World territories, the concept of an agglomeration of integrated industries capable of generating a high level of growth remains questionable.

The functional land use pattern associated with transport investments has been the object of many modeling approaches (Di Giampietro, 1989). All share the aim of understanding how to optimize the interrelationship between different types of functional land use in a given territory and how to structure a territory on the basis of these interactions. The spatial interaction models used in transport planning assume that there exists an equilibrium between traffic flows and activity locations in urban areas. The problems appear when these models are used to predict activity locations by interpreting the trip destinations of the traffic model as residential, industrial, commercial and institutional (Bly and Webster, 1984). More specifically, these models predict location which is a slow and inert process, from traffic which is a volatile and flexible process. The main deficiency of

most current modeling approaches can be identified as neglect of the integration of existing geographical knowledge in regard to the ex ante transport/land use modeling approaches, with its focus on territorial dynamics and theory development (Prud'homme, 1989; Rice, 1989).

This paper addresses this aspect of the problem by introducing a theoretical and methodological framework for the analysis of the interrelationship between land uses. For the purpose of the present endeavour, this analysis will attempt to determine to what extent the functional land use in a city can be considered an ordered pattern. The order sought does not rely on purely spatial configurations, but on the correlation of transportation and land use. In this sense one may speak of territorial order.

The first section of this paper focuses on theoretical considerations. It stresses the fact that conventional approaches to modeling do not apply in the present context. It then suggests an alternative based on areas of influence and measured in terms of level of attractance of land uses. The second section describes a procedure based on this alternative following the remarkable contribution of Hanjoul, Beguin and Thill (1987). An application of this procedure to the analysis of Shanghai is then examined. Finally, an evaluation of the strategies for optimizing the interrelationship between land uses is presented. The paper concludes on a possible research agenda.

2. THEORETICAL PERSPECTIVE

Since the eighties, the need for improved territorial planning has fostered the concern for developing a theory encompassing urban change and spatial mobility. As a result, much research has concentrated on understanding the process of urbanization and the mechanisms of transport technology and, above all, on charting their complex interrelationships. The urban field must be

understood as the territorial unit whose functional land use components are defined on the basis of internal exchanges of goods, people and information; while transportation is the communication and circulation potential between the various activities that characterize functional land use. Transportation and land use can thus be conceived as a system through the traffic they generate as the joint result of the level of activities of functional land use and transport capacity. These interactions between places is at the root of a territorial system whose development is the result of both spatial extension and functional integration.

The purpose of the present inquiry to be carried out among various districts in Shanghai is to measure the relationship between land use function and transportation. The research hypothesis is that the interrelationships between land use and transport must be based on a new definition of the concept of distance.

Distance is a term which in its narrow sense is the spatio-temporal interval between points, and in its wider sense implies both recognizing distance and trying to cancel its effects. Recognizing distance means to distinguish properties of places by their land use content. To cancel the effects signifies to make explicit the geographical conditions of accumulation of functional land uses and to establish strategies allowing to satisfy these conditions. The study of distance can thus point at a set of attributes of places and it can look for more dynamic features such as links, interaction and network explaining the mechanisms of territorial processes.

Two main theories have been concerned with territorial structures: the central-place theory and the growth pole theory. These theories basically challenge the form of territories (location, mode of distribution, appropriate infrastructures), whereas a territorial logic must also consider the content of territories (control over the relationship between centre and periphery,

geographic distribution of the conditions of accumulation, historical analysis of uneven development). In this context, the processes of spatial organization remains analytically inadequate without an understanding of the mechanisms that govern it.

The organization of space depends on the strategies and the objectives of a given community concerning land use and transport. But, to the extent that the control of territories implies transport, then its relation to space and time is significant. Spatial geometry includes relative position, distance, and the angle between different directions within a territory. As a result, land uses are characterized by length and form, which are determined by the distances between land uses and the direction taken by the growth of land use functions. The characteristics of time are the moments at which phenomena occur and the duration of processes. From a relational perspective, space and time must be considered together. In fact, spatial and temporal relations manifest their unity in the coordination of the conditions of accumulation and the circulation of goods, people and information. Given the irreversibility of time and the finity of space, the temporality of any action inscribed in a given space implies a close relationship between duration and the structure of a territory in the overcoming of distances. Under the changing conditions in the location of resources and the development of interactions, a territorial logic must be considered under the organizational relationship of symmetry and asymmetry.

By definition, symmetry with the existence of true correspondence prevents both the growth of territorial structures to the detriment of others, and territorial disintegration. Symmetry is a guarantor of differences and of pluralism. Asymmetry favors the growth of territorial structure to the detriment of others. Therefore, from a specific level of accumulation, there is a possibility to derive a particular territorial form. Without always

measuring precisely the equivalence between level of accumulation and spatial form given the varied conditions of territories and networks, which would establish a typology, territorial patterns exhibit a spatiotemporal dynamics. Some are orderly in space but disorderly in time. Others are orderly in time but disorderly in space. The dynamics is very basic: forms changing in space and time at different geographical scales. It follows that a low degree of territorial order exhibits an asymmetrical territorial pattern while a high degree of order indicates a time-space convergence ensuring a corresponding level of accumulation among all types of land use functions.

Land use and transportation modifications reflect changes in the level of accumulation from diffusion to concentration, from order to increasing disorder. Consequently, the underlying mechanism in the process of territorial pattern is the product of imbalance in the flow of accumulation from one land use function to another in a simple deterministic system, resulting in the creation of areas of influence for each type of functional land uses. This process acquires its fullest significance in terms of movements and changes in the mutual causality of time and space. In this perspective, determinism assumes the capacity of communities to choose goals and to make efforts essential to their realization. A symmetrical territorial pattern requires both changing the land use function that allows a geographical distribution of the conditions of accumulation, and optimizing traffic flows. Unless both are done at the same time, it is unlikely that territorial order can be achieved.

3. METHODOLOGY

In order to measure the causality between the geographic conditions of

accumulation and the structure of a transport network, the most fruitful method is spatial interaction modeling. Such an approach can produce a distinct territorial pattern explaining the dynamics of uneven regional development. Measurements of territorial order will focus on structure and interaction.

Following the remarkable contribution of Hanjoul, Beguin and Thill (1987), the intention is to identify and explain the form and size of areas of influence in various districts of Shanghai, to analyze areal differentiation according to land use characteristics and to evaluate the degree of territorial order in the city.

Let $F(d_{ij})$ be a decreasing function of distance between center j and some point i.

Let $G(A_{ij})$ be a function of the attractance A_{ij} of center j on some point i.

We want to determine the areas of influence Z_k of center k.

First, for each point i we define

$$N_i(k) = \sum_{\text{center } j \neq k} \left[[\ln F(d_{ik}) - \ln F(d_{ij})] - \ln \left[\frac{G(A_{ij})}{G(A_{ik})} \right] \right] \quad \forall\, k.$$

where the value of $N_i(k)$ is influenced by the difference of the advantage of k in terms of proximity and the advantage of k in terms of attractance.

Then, $i \in Z_{\bar{k}} \iff N_i(\bar{k}) = \max_k N_i(k)$

the membership of i to an area of influence is determined by the highest value $N_i(k)$.

For simplicity, we take

$F(d_{ij}) = 1/d_{ij}$

$G(A_{ij}) = A_{ij}$

Each of the 316 points of intersection in a transit origin/destination matrix for a home-based work purposes survey conducted in 1982 was located on a base map of 11 of the 12 urban districts of Shanghai. Having the exact coordinates of three points, it was possible to find the respective longitude and latitude of all the points of intersection. The o/d matrix was then transformed into points of origin and urban district center points of destination. The longitude and latitude of each district centroid was calculated according to the center of the smallest circle encompassing each district. The euclidean distance expressed in kilometers between each point and each district centroid was calculated (d_{ij}). The attractance of each district was calculated from the total number of persons traveling to each district from each point of origin (A_{ij}). The boundaries of areas of influence for the eleven urban districts of Shanghai were then traced at the median line between two points belonging to different areas of influence.

4. THE APPLICATION TO SHANGHAI

Since 1981, China has adopted new economic development strategies. These strategies rest partly on the transformation of production activities and on an increase in foreign trade. With the integration of China into the world economic market, the Chinese authorities wish to bring on foreign investment and technologies to finance developmental projects and modernize China's industrial infrastructure. But one of the necessary conditions for the reorganization of industrial space to be successful is territorial accessibility. Indeed, the optimization of relations between different types

of land use is part of the efforts toward China's modernization process.

This is particularly true in the case of Shanghai, which is not only considered as one of the most important industrial bases of China but also the largest port city in the country. Because Shanghai does not have any raw material or sources of energy, the municipality depends entirely on external sources for supply. The development of an efficient transport system is thus a prerequisite for any far-reaching economic goals. Technologically, Shanghai's transport sector is dual. Traditional means of transportation exist in large numbers alongside a growing modern transport system.

An examination of modal freight transport reveals that labor intensive and traditional means of transportation on roads are important in short distance freight transport (Table 1). Moreover, freight traffic per capita suggests that road transport is dominant. As a result, traditional means of transportation often reduce the capacity of modern roads. The modern sector was first developed to meet the needs of heavy industry. But the recent shift in emphasis to light industry and agriculture implies a lesser growth rate than in the past for the movement of bulk commodities and a faster growth rate for consumer goods. Since these products move over shorter distances and between many dispersed origins and destinations in small shipments, they are more suitable to road transport.

The emerging demand for passenger transport is one of the key issues of the transport system in Shanghai. After an upward trends, the average trips per capita appears to stabilize since 1987 (Table 2). Although passenger traffic has expanded since 1949, the Chinese are still relatively immobile. This low mobility essentially results from the low density of the road transport network, as well as its limited capacity. Table 2 indicates that the route lenght is increasing at a much faster rate than the number of public vehicle in service. This low mobility is a concern for the development and the

Table 1

Freight Transport Performance of Major Modes in Shanghai, 1987

Mode	Freight density (million metric ton-km/km)	Average length of haul (ton-km/ ton)	Average ton originated per capita (ton/pop)
Road	0.49	13.03	8.04
Water	0.97	96.29	1.99
Rail	15.57	283.69	1.07

Source: China Statistical Yearbook 1988

Table 2

Urban Public Passenger Transport Performance in Shanghai, 1985-1989

Year	Average daily trips per capita (pass/pop)	Average daily ridership (pass/ vehicle)	Vehicle density (vehicle/ km)
1985	1.13	2726	0.50
1986	1.15	2580	0.39
1987	1.22	2591	0.37
1988	1.22	2562	0.34
1989	1.18	2480	0.35

Source: Shanghai Statistical Yearbook 1990

extension of services such as education and health to rural areas where service is low and access difficult. The Shanghai transport sector is already congested. But population growth and an increase in personal income resulting from economic expansion will generate greater pressures on the urban transport system in terms of the number of people wanting to travel. Shanghai must increase the capacity of its transport system. In 1989, Shanghai metropolitan area covers 6340 square kilometers with a population of 12.7 million, of which 7.7 million concentrate in the central city urban districts of 230 square kilometers. The street system of the center city is a product of the European concessions that played a major role in the development of the city. The length of urban streets is 1674 km, constituting less than 10 percent of the land area. Streets have an average width of 13 meters. Road area per capita is less than 3 square meters.

In the general context of widening economic production and efficient land use interactions, the Shanghai authorities have undertaken three main tasks in order to solve their transportation problems and to maximize freight and passenger transport: 1) upgrade route sections which have already reached congestion levels at their present design standards to face the demand potential resulting from economic policy changes, 2) optimize route and transit network planning to induce a shift in demand away from equipment and toward better scheduling, 3) change the land use pattern of the municipality to divert traffic in the transport system.

The Shanghai government has already taken specific steps to increase territorial accessibility. Recognizing the need for a comprehensive land use/transport approach, the Chinese are planning the development of a new area, Pudong, on the east bank of the Huangpu river. (Pudong Development Office of Shanghai Municipality, 1990). Most of this area is within a radius of 15 kilometers from the city's present down-town area (Puxi). Pudong covers

an area of 350 square kilometers and has a population of 1.1 million. Two ring roads will be built. A new pattern of the city's central districts will be formed with the Huangpu river running through the center. The inner ring road will be 45 kilometers long and will encompass an area of 120 square kilometers, including both Puxi and Pudong. The outer ring road will be 89 kilometers long and will enclose an area of 570 square kilometers (including the inner ring road area), roughly the size of Singapore. This road will link various industrial zones and residential areas and will serve as a terminal boundary of the city's urbanization development. Ten radial roads between the two ring roads will be built so as to form a convenient urban transportation network. The municipality's comprehensive plan anticipates the construction of new harbors located at the periphery (Comprehensive Plan of Shanghai, n.d.). Strategies also include diverting rail traffic away from the old inner ring. The extensions of Hongqiao airport will be quickened to face the demand of Shanghai as a modern international economic and trade center. Since Longhua and Jiangwan airports are located within the boundary of the inner city, thus greatly affecting flight safety and urban development, the Shanghai authorities plan to relocate Jiangwan airport and change the land use nature of Longhua airport. An international airport will be built near the estuary of the Changjiang in Chuansha county. Four national highways, four local expressways and a subway are being constructed to alleviate urban traffic. This plan will require massive population transfers and important housing schemes. The Chinese are investing enormously in the construction of various and costly infrastructures. In this context, any approach that would increase the efficiency of the transport network while optimizing public revenues is certainly timely.

Changes in the transport system affect the accessibility of locations. In addition, locations with high accessibility attract more development than less

accessible ones thus changing the functional land use pattern of a region by influencing the distribution of activities in a territory. These activities in turn generate traffic in the transport system. Thus a wide range of scenarios including different elements from any, or a combination of the courses of action outlined above can be imagined.

Spatial equality implies equitable areal access to the opportunities society provides. If certain regions are allowed to concentrate important economic activities and thus to prosper first, will decisive measures be taken at the appropriate time to channel the increased resources to the less developed regions? And if so, in what ways and how will the spatial imbalances in levels of development be resolved? Or does the attainment of one goal, modernization, even if only partial, prevent or subvert the attainment of another, territorial order?

The need to answer these questions is obvious given the simple and sometimes uncritical faith that is put into the process of modernization and in view of the necessity to consolidate functional land use and transport system, and to estimate their effects on territorial policy.

With the opening of Shanghai to the world economic market, several observations have been made concerning territorial development in the municipality. Fung (1981), for instance, examines satellite town development in Shanghai. The main objective in the establishment of the core area of Shanghai was to provide a wider range of sites to be selected for industrial district and satellite town development. The incorporation of this large territory into Shanghai enabled the authorities to locate future satellite towns at an optimal distance from the central city. This would prevent the latter from being absorbed into the former thus aggravating the problem of rapid expansion of built-up areas of large cities, while retention of certain mutual coordinations in industrial production was possible. In another vein,

Ding (1984) analyzes the economic zones of Shanghai. Taking Suzhou, Wuxi, Changzhou and Nantong as references, he examines their respective functions and evaluates the potential of their complementarity. He concludes that the four cities have functioned as development poles with Shanghai as the primary node. Taking the analysis a step further, Yu and Gu (1984) illustrate how the active development of small towns is an effective and practical approach to the gradual realization of rural-urban integration. But they also stress that the building of satellite towns has not made an appreciable contribution to the decentralization of population in Shanghai considering the enormous investment the state had to provide. As a result, the building of satellite towns must not be considered as the only remedy for solving the problem of the metropolises. This is exemplified by the research of Zhang (1984) on the problems of administrating counties in the Shanghai economic region. While Shanghai has lent technological and economic support to agriculture and industry over a wide territory, and has allowed the establishment of joint ventures with enterprises in peripheral towns that strengthen their economic bases, Zhang demonstrates that Shanghai, in its relation with peripheral towns, has passed on the problem of waste disposal, thus accentuating environmental pollution. Nevertheless, linkage mechanisms in the decentralization process remain essential to the process of territorial order. Exploring the complex relationship between communication and transportation in the urbanization context, He (1984) examines their respective characteristics. The conclusion of his argument is that the traffic problems constitute the major hindrance in the economic development of Shanghai. More specifically, the direction of flow is unbalanced, port construction has fallen behind the development of production and trade, the advantages offered by a dense network are not fully exploited and there is a lack of coordination between modes. In a more specific manner, Chen (1984) examines

maritime transport and looks for variations in economic and geographical factors to explain seaport location and development. He recognizes the existence of overlapping hinterlands served by several competing ports and that complementary functions are developed in systems of ports which may evolve into a hierarchy of pivot and subsidiary ports. In a more geographical manner, several studies have taken into account the existing land use pattern and its constraints. Hong (1984) describes the industrial context of the region and stresses the need for rejuvenation of equipment and technology, industrial specialization and environmental protection. Taking the iron and steel industry of Shanghai as case study, Yang (1984) suggests that a special quality of steel and steel products be developed that further expansion of steel capacity be halted and that some plants be relocated to suburban areas with a view to rationalize the development and location of the industry in Shanghai. Concerned with the commercial importance of Shanghai, Ning (1984) uses the technique of cluster analysis to understand urban shopping center location in Shanghai. The integration of functional land use and transportation is inherent in the development of Shanghai. It manifests itself in two ways: long-term influence of transport on the location of activities, and short-term influence of land use on demand for transport. Wu (1987) analyzes the transit system of Shanghai with the help of the EMME/2 system, the most advanced interactive-graphic tool for the planning and evaluation of urban transport multimodal networks. Based on this analysis, he has suggested improvement of the current transit system that would provide better traffic conditions in the downtown area. Fabre (1988) has clearly demonstrated that the economic strategies of Shanghai rest on the complex articulation and dynamics of economic, industrial and urban restructuration. Antier (1988) brought further arguments by demonstrating that Shanghai is characterized by a core that is marked by the daily contradictions of poor

housing conditions with housing scheme policies that underline the inadequacy of public transport to employment locations in the city core. Simultaneously, Comtois (1989) analyzes the problems emerging from a new spatial configuration in Shanghai in the context of enlarged production. He recognizes the double complexity of transport and territories and stresses the need to develop new operational planning tools allowing to undertake rapid actions concerning transport problems linked with the development of the city.

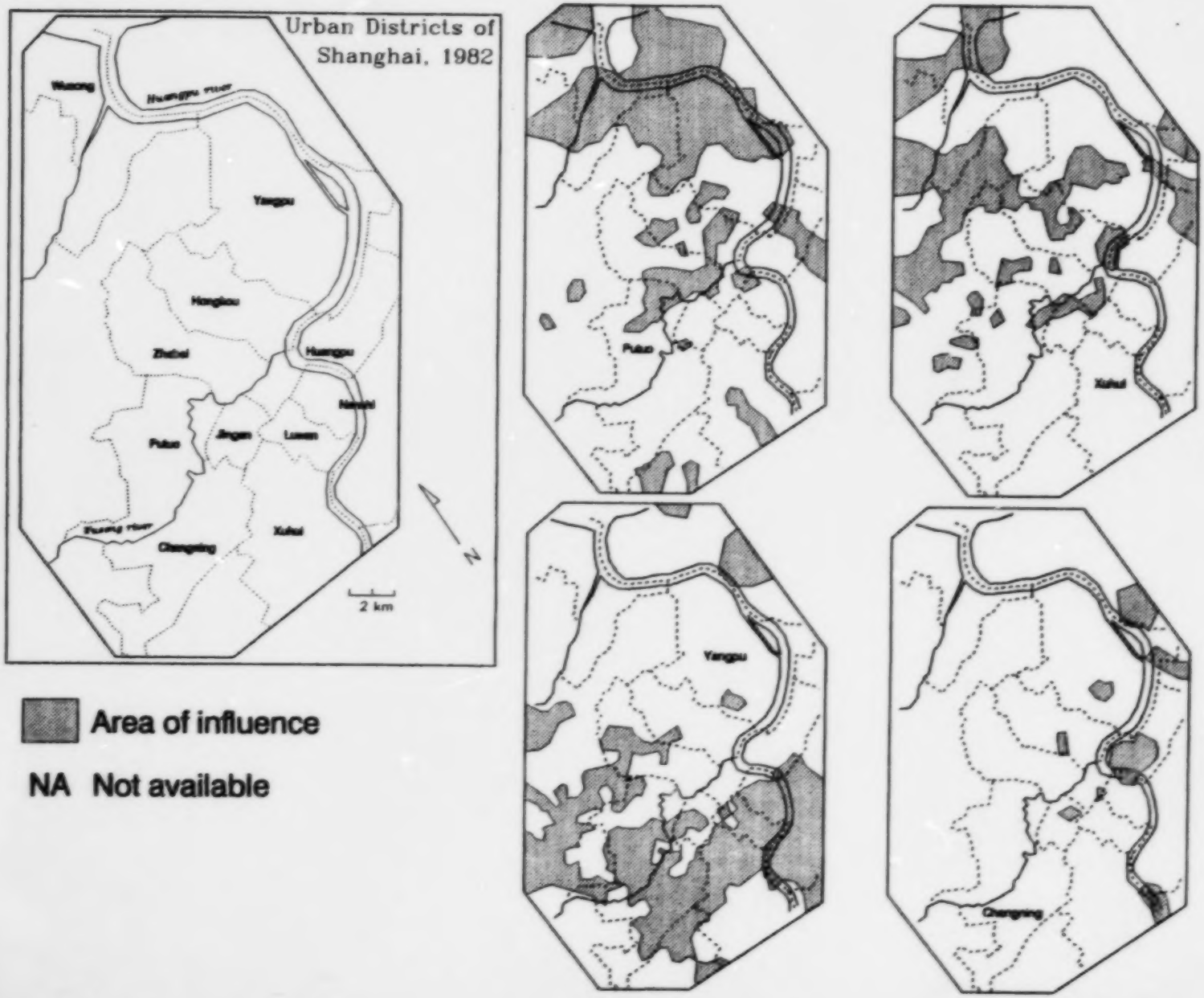
There is a wide spectrum of studies on Shanghai's territorial logic. But very few, if any, are based on a systematic comparison between the costs of overcoming distances and the level of attractance. It is believed, therefore, that a thoroughly reliable basis for the elaboration of a land use/transport model in Shanghai be impossible unless this field of evaluation is carried out.

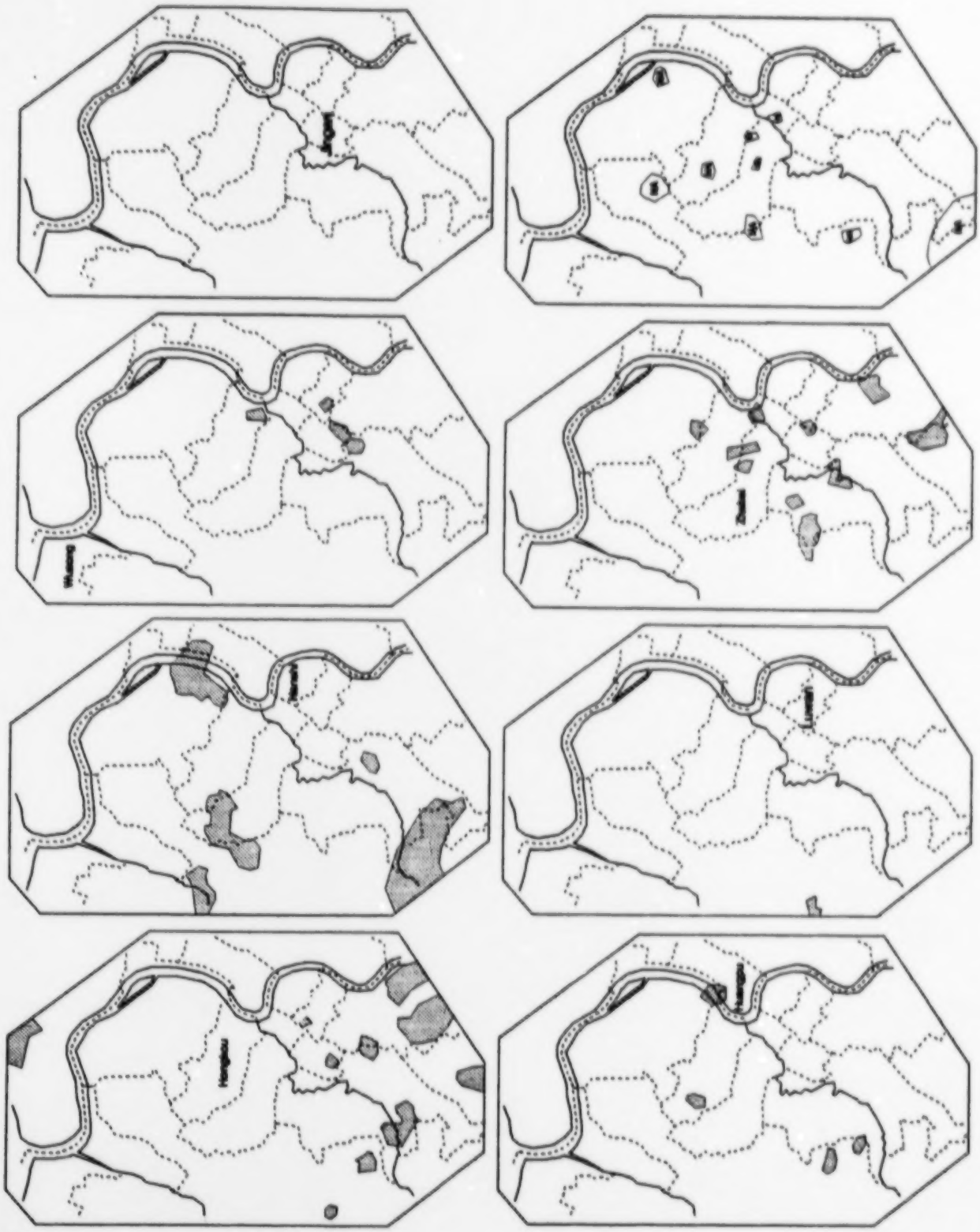
5. PRELIMINARY RESULTS

Given the magnitude of data available, Shanghai provides an excellent illustration to test the equation. First, figure 1 reveals, that the areas of influence can be clearly demarcated, the forms of the boundary have an irregular shape, they are not fully connected, and are made of separate components. Indeed, some urban centers do not even belong to their own area of influence. This is the case for the urban districts of Nanshi, Hongkou, Jingan, Luwan, Wusong, Xuhui and Changning.

This may be explained by the fact that networks are maintained by nodes located at different hierarchical levels. At the summit, in Shanghai, are the maritime gateways which are multimodal nodes exceeding the limits of regional space. But the development of a multimodal transport system was not linked to functional land use nodes within the municipality. Referring to passenger

Fig. 1
Areas of Influence in Each District of Shanghai, 1982





movement in Shanghai, the average number of transfers is 1.19 while the average transit time is 51.42 minutes. Besides, the large origin trip areas are more clustered while the large destination trip areas are more diversified (Figure 2). As a result, the transit network of Shanghai cannot be generalized as a cluster, grid or radial-type network, but rather as a mixed transit network composed of a variety of bus lines in all directions forming different patterns. This is necessarily reflected in the areas of influence of the various districts of Shanghai.

Secondly, figure 1 also reveals that the area of influence of most of the district of Shanghai is highly dependent on the attractance weight of Putuo, Yangpu, and Xuhui. The urban districts of Yangpu and Putuo are located at both ends of the main water artery of Shanghai represented by the Huangpu and the Wusong rivers. Figure 3 reveals that these areas of influence are at opposite ends of the urbanized surface of the metropolis.

How much of the variation in the spatial form of the areas of influence is explained by the level of accumulation? For the purpose of answering this question, multiple regression analysis was used. The dependent variable for the analysis was the total size of the areas of influence of each district, whereas the independent variables included various aspects of territorial accumulation. In the present context, territorial accumulation refers to a package of land use functions, several of which are interrelated, and become, in time, directly interdependent. They include those aspects of geographic accumulation which can be quantified and for which there are reasonably accurate and comparable data at the district level. The set of independent variables comprises demographic (total population and population density), land use (industrial, school, office, commercial and warehouse areas), and industrial (total number of industrial enterprises and industrial production) variables, which are deemed to have a possible effect on territorial form of

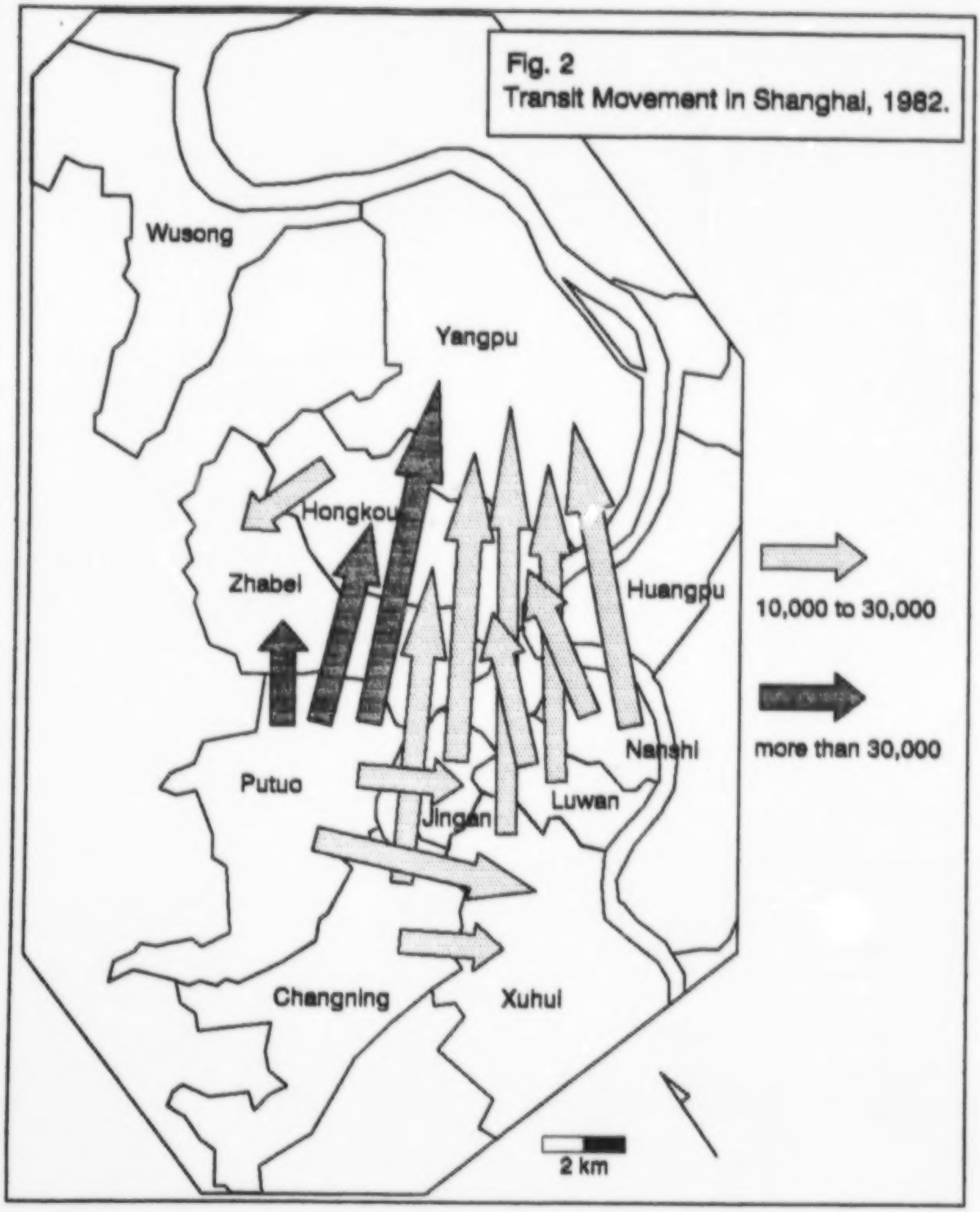


Fig. 2
Transit Movement in Shanghai, 1982.
Wusong
Yangpu
Hongkou
Zhabei
Huangpu
Nanshi
Putuo
Jingan
Luwan
Changning
Xuhui
10,000 to 30,000
more than 30,000
2 km

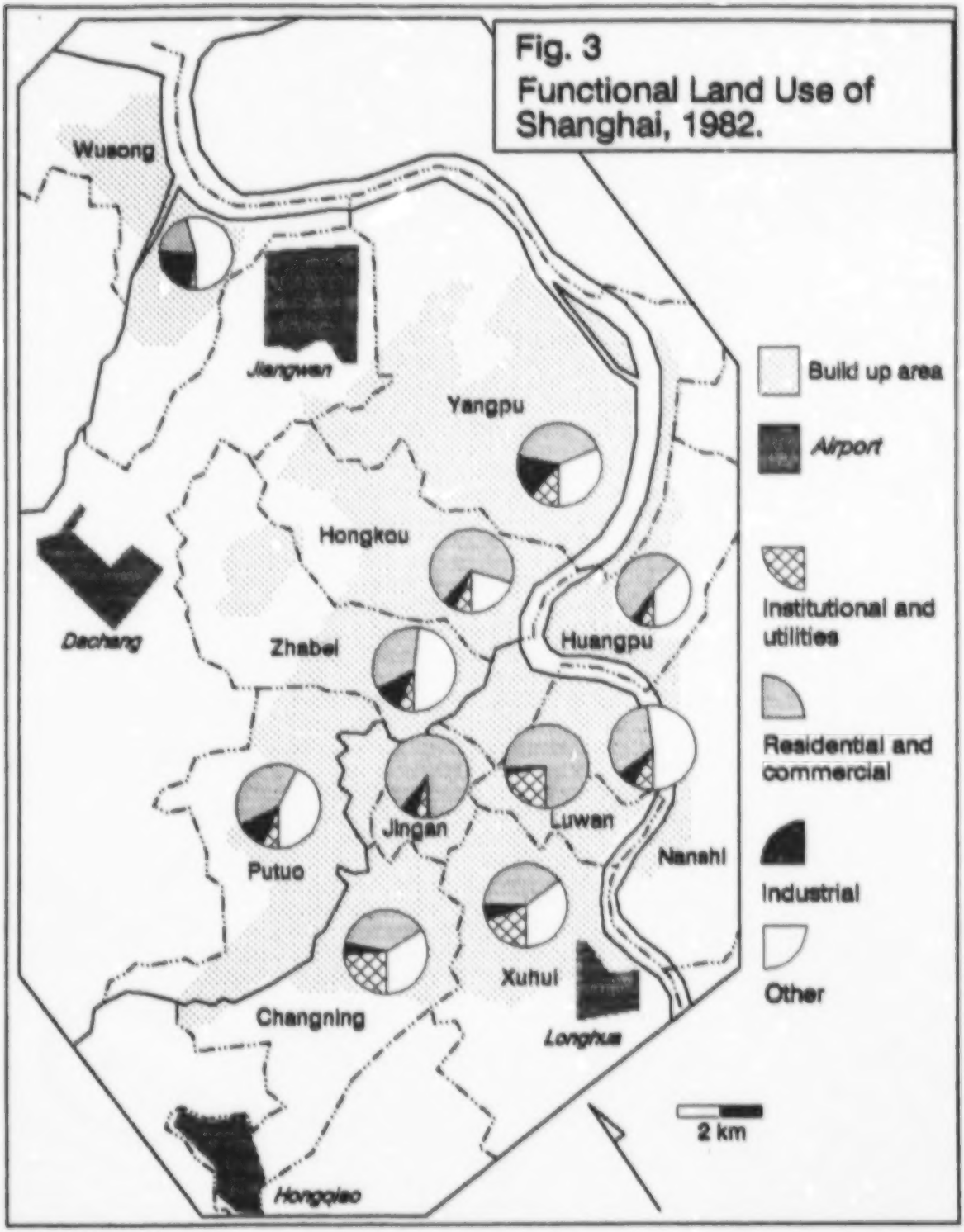


Fig. 3
Functional Land Use of Shanghai, 1982.
Wusong
Jiangwan
Yangpu
Hongkou
Dachang
Zhabei
Huangpu
Jingan
Luwan
Putuo
Nanshi
Xuhui
Changning
Longhua
Hongqiao
Build up area
Airport
Institutional and utilities
Residential and commercial
Industrial
Other
2 km

the areas of influence of Shanghai. By using the stepwise regression analysis, research findings reveal that the multiple regression coefficient, R, is 0.79. Industrial area accounts for over 63% of the variation in the dependent variable. In fact, the districts of Putuo, Xuhui, and Yangpu together account for 43% of the industrial area and 35% of the urban area of Shanghai. Besides, 40% of all the built-up area except for housing is located in those three districts (Figure 3).

At this point, more insight concerning the role of accumulation in providing a comprehensive understanding of the spatial form of the areas of influence may be gained by examining industrial performance. Table 3 indicates that there is a clear distinction between labor and capital productivity. The output per square meter is greater for light industry than heavy industry. This would suggest that as the Chinese economy diversifies, more of the industrial output value originates from the production of consumer goods. The figures also imply an inverse relationship between population density and output per capita. This would point to factors of modernization (the highest labor productivity is found in highly mechanized industrial areas) and demography (areas of high population density generate lower level of accumulation per capita). There is thus a definite relation between the spatial form of the areas of influence on the one hand, and geographic accumulation on the other hand.

Based on the numerical results obtained from the equation, a number of properties can now be stated:

1. The equation is a simple and effective measure that gives a good discrimination between centroids.

2. An area of influence can be spatially delimited because the differences between transport costs can be effectively compared to comparative attractance.

Table 3

Industrial Performance of Urban Districts of Shanghai, 1987

Districts	Population density (persons/ square km)	Industrial density (industrial surface/area) (%)	Light Industry		Heavy Industry	
			output per capita (yuan)	output per square meter (yuan)	output per capita (yuan)	output per square meter (yuan)
Huangpu	33 880	5.7	2 692	1 590	1 538	908
Nanshi	30 353	9.7	2 939	922	3 372	1 058
Luwan	58 597	3.4	4 382	7 579	2 726	4 715
Xuhui	14 713	6.0	8 161	1 993	3 760	918
Changning	18 039	6.1	5 359	1 583	3 826	1 130
Jingan	63 766	8.4	6 094	4 653	2 373	1 812
Putuo	23 678	16.2	6 269	916	2 731	399
Zhabei	24 127	14.7	3 710	608	3 919	642
Hongkou	35 416	9.1	3 936	1 529	2 583	1 004
Yangpu	17 188	21.2	8 148	661	7 248	588
Wusong	4 046	15.9	3 146	80	19 919	507
Minhang	3 060	4.9	979	61	17 618	1 090

Source: Shanghai Statistical Yearbook 1988

3. An area of influence is connected (i.e. all in one piece) if and only if any two points of Z can be joined by a path contained in Z.

4. Two points that are closely connected by a transport network tend to be part of the same area of influence. The form of boundary of areas of influence varies from convex to concave according to the transport cost difference between centroids.

5. The size of an area of influence is a decreasing function of comparative attractance.

6. The size of an area of influence is an increasing function of the distance between centroids.

6. STRATEGY FOR THE INTERRELATIONSHIP BETWEEN LAND USES

Firstly, the above analysis reveals that the greater the disparities in the factors of geographic accumulation and transportation, the lower the degree of territorial order. Secondly, achieving a symmetrical territorial pattern can only be relative owing to development process disparities among various functional land use. This imbalance is inevitable given the contradictory processes of concentration and diffusion. The asymmetrical territorial pattern of Shanghai is marked by continued concentration in a few functional land use, traffic congestion, high population density, and environmental problems, as well as by land shortages. Given the limitations in capital, material, and territorial infrastructure, a more orderly territorial structure can only be achieved by gradually encouraging variation in land use function on the edge of transport corridors. The interrelationship between land uses refers to the diffusion of development through land use functions (nodes) and axes. Priority development is granted to various land use functions located along transport infrastructures. The main focus is not on growth pole but on

the optimization of existing axes. This issue can be resolved by considering the interrelationship between land uses as an integrated system.

One: the essence of the interrelationship between land uses is not to increase the value added to production but to improve the quality of service along a transport network, especially of short distance transport. Indeed, the dispersed spatial pattern of metropolitan areas which result from route expansion are likely to prove all but impossible to serve with transportation facilities in any energy-efficient fashion, hence the importance of short distance transport in port cities where freight, passengers and information transit on the same network.

Two: the interrelationship between land uses permits land use functions to play their full roles thus shifting development away from high order centers to axis development. The centralization of vast industrial zones in terms of real estate, economics or technical level cannot guarantee that the industrial units be maintained, or prevent a slowdown of economic activities. While development induced by the intimate links between a basic transport infrastructure and the exchange process yield multiple points of concentration.

Three: the interrelationship between land uses can best realize territorial integration along a linear infrastructure where geographic accumulation would correspond with the location of circulation lines thus avoiding a spatiotemporal gap in areas of influence. The linear city would prevent multidirectional transport affecting the level of continuity in areas of influence. Besides, Asplund (1984) has demonstrated how linear urban growth increases functional land use and transport efficiency.

Four: the interrelationship between land uses would improve functional land uses cooperation resulting in the appearance of center-periphery integration. The intention is clearly to make full use of the central role of large cities.

Only in the long term would urban expansion occur in a manner reducing population growth in the city core thus creating the necessary conditions for relocating industry and population in peripheral areas.

Five: the interrelationship between land uses by selecting key development axes within a city or a region would identify a clear direction for the diffusion of the conditions of accumulation.

Six: the interrelationship between land uses would best achieve the joint planning of functional land use and transportation system.

7. RESEARCH AGENDA

A city is a system of functions in which transport is the bonding subsystem between territorial activities. In geographical terms, urban form is divided into various types of functional land use; while there is a multiplicity of modes. The interdependence of transport and urban development has been illustrated and the problem of lack of integration is particularly acute in Shanghai.

Traffic demand forecasts for Shanghai foresee a continued expansion of transport up to the end of this century. This increase in demand will necessitate new operation techniques that will consider the growth in volumes, the evolution in the nature of goods in circulation and the major changes pertaining to urban functional land use in the municipality.

The first definite policy for future development of the relation between land use and transport infrastructure is to classify functional land use in accordance with the effect on modal traffic that they generate. There is a continuum of modes that differ in terms of carrying capacity, technology, and costs. The notion of modal choice with regard to land use function will have to be reconsidered.

The productivity of existing transportation services for functional land use varies considerably. Unfortunately, information on why these productivities vary so greatly is insufficient. Research is needed to isolate the specific characteristics of transportation services that have a definite impact on geographic accumulation, more specifically to evaluate how work assignment creates a geographical transfer of revenues.

Finally, the theory of area of influence provides a geometric analysis of transportation and the interrelationship between land uses. Even though sound in theory, preliminary results indicate that the model is descriptive of the mass phenomena in Shanghai rather than being dynamic. The model cannot be used to derive trends and prognosis on the urban territorial structure resulting from changes in the transport system; neither is it possible to draw specific conclusions from areas of influence to the shortcomings in the transportation system and the need of its improvement. The application of Shanghai home-based purposes survey is to an aggregate approach. Besides, the use of physical distance rather than travel time or energy cost doest not reflect the traffic quality of the urban transit system. Future research on areas of influence will have to be based on functional land use and transport network at a more disaggregated level.

8. CONCLUSION

Urban policy making in transport location and land use are intertwined in their consequences. Harbor territories in Shanghai await other land use functions. The development of the network, the establishment of nodes and the rationalization of services for the establishment of a basic transport infrastructure are linked to the needs of industrial development. If such changes to the transport system were made then the problem of what types and

how to deal with the impact that would be expected on the location of activities and the ultimate characteristics of the transport system over the next several decades is currently one of the most critical public policy problems. Such a policy or policies will have to seriously consider the theoretical aspects of areas of influence, and the relational perspective of geographic accumulation and transport network.

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